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PALEONTOLOGY.—*Significance of divergence of the first digit in the primitive mammalian foot.* JAMES WILLIAMS GIDLEY, U. S. National Museum.

In connection with some recent research work on Basal Eocene mammals I have had occasion to make a critical study of the primitive mammalian foot, especially as regards the meaning of divergence of the first digit. On the interpretation of this character depends in no small degree our concept of the early life history of the Mammalia.

Based on certain modifications observed especially in the hind feet of marsupials, including divergence and opposability of the hallux associated with a tendency to enlargement of the fourth digit and reduction and syndactylism of the second and third digits, Huxley in 1880[1] expressed the view that the existing marsupials have been derived from an arboreal ancestry. Later Dollo,[2] in full accord with this view, discussed the evidence for it at considerable length. Soon followed a review by Bensley[3] in which he expressed general agreement with the interpretation of Huxley and Dollo. In 1904 Matthew published an article on "The Arboreal Ancestry of the Mammalia,"[4] in which he accepted the views of Huxley, Dollo, and Bensley regarding the arboreal ancestry of the marsupials, and expressed his belief that the

[1] Proc. Zool. Soc. Lond., p. 655.

[2] *Les ancêtreses Marsupiaux etaient-ils arboricoles?* Miscellanées biologiques, 1899.

[3] Amer. Nat. 35: 117–122. 1901.

[4] Amer. Nat. 38: 813–815. 1904.

placentals are likewise of arboreal origin. This latter belief was apparently based, principally at least, on the fact that the first digit, in both the fore and hind feet of the early Eocene mammals of generalized type, is so frequently found in a divergent position, and on the condition found in the earliest known Primates. But unlike Huxley and Dollo, who considered arboreal adaptation in the marsupials a specialization and not a primitive condition, Matthew advanced the hypothesis that opposability of the first digit in the early mammals was a primitive condition. While I do in the main indorse Matthew's characterization of a hypothetical "common ancestral group," I am unable to agree with him regarding arboreal ancestry as applied to placentals in general, and therefore differ from him in the interpretation of the conditions found in the primitive mammalian foot. In order more clearly to set forth my own view I here quote the principal arguments advanced by Matthew in support of his interpretation:

> (1) In the first place, as far as we can trace back the history of each of the arboreal groups, we find their first ancestors with the first digit as fully opposable as in the modern representatives (*e. g.*, the Middle Eocene primate *Northarctus*).
>
> (2) Second, in those groups which have not an opposable thumb, we find as we trace back their ancestry that the trapezium, whose form and facets give the surest indication on this point, approaches more and more nearly to the type preserved in the Primates, etc.
>
> (3) In the four Basal Eocene mammals (Pantolambda, Euprotogonia, Claenodon, and Dissacus) in which this part of the skeleton is known, the form of the bone [trapezium] is surprisingly uniform, and when the manus is put together, the first digit is thrown partly outward from the rest of the hand, and permits of much freer motion than the remaining digits, with a considerable degree of opposition.

Following this, in the same article, Matthew states that the primitive opposability of the hallux is less clearly indicated but suggests this is due to the probability that the evolution of the hind foot for terrestrial locomotion "began earlier or proceeded more rapidly." He further suggested that "the hypothesis that all mammals passed through a stage when the pollex and hallux were opposable," would explain among other things, "(*a*) the presence of but two phalanges on digit 1, three on each of the others; (*b*) the epiphysis of digit 1 being proximal as in the

phalanges, instead of distal as in the remaining metapodials; (*c*) the anomalous musculature of digit 1 on all mammals, the object of which is clearly seen when the digit is opposable, but is quite unexplained otherwise." In further substantiation of the arboreal ancestry hypotheses, Matthew's first proposition above quoted has, I believe, little weight as evidence. First, because *Notharctus* can hardly be considered primitive, since the known species, even in the Bridger epoch, had advanced in foot, limb, and skull structure well toward the condition found in the present-day South American apes; second, admitting *Notharctus* to be primitive, the presence of true opposability in this genus can affect the proposition under discussion only so far as the Primates themselves are concerned, and cannot be taken as evidence of arboreal ancestry for other orders of mammals, especially as there is no indication of close relationship between any of them and the Primates.[5] At most the evidence in the case of *Notharctus* can not be interpreted to mean more than that the group which it represents (the Primates) had adapted themselves to an arboreal habitat at a comparatively early period. But opposability probably followed or accompanied and did not precede their adaptation to tree-living habits. If this be true it explains why there are so many cases in which opposability has not been developed even in strictly arboreal forms, and likewise why these cases seem to be confined to species of comparatively small size. For example, many species of rodents and insectivores are living to-day almost exclusively in the trees, yet, so far as I am aware, there is not one example of true opposability among the Insectivora, and but one among all the Rodentia, living or extinct. This single exception is furnished by the African genus, *Lophiomys*, in which the first digit of the hind foot is thus developed, and this animal is not arboreal. Among the Insectivora some of the Tupaiidae are mostly arboreal in habit, more so than in any other members of the order, yet even in this family there is not the slightest trace of opposability.

[5] It may be here remarked that, in my opinion, there is some evidence that this important order, and probably some other orders of mammals as well, have been derived independently from different though probably more or less closely related premammalian ancestral groups.

Among the Primates themselves there is a whole group of living species, the South American marmosets, that, in the fore feet at least, show no evidence of opposability, although they are strictly arboreal in habits. These smaller, lighter-bodied animals seem never to have acquired the function of grasping a limb, but depend rather on their sharp, widely spread claws for support in progressing among the tree tops.

Matthew's second and third propositions, above quoted, do not strictly concern opposability but refer rather to simple divergence of the first digit. And the crux of the whole proposition seems to lie, after all, in the interpretation of this condition.

"Primitive opposability" and "more or less opposable" are terms which the advocates of arboreal ancestry have frequently used, but have never clearly defined. These terms seem to express a condition somewhat different from the kind of opposability developed in the modern Primates, and as used by Matthew, as I interpret it, seem to imply that simple divergence of the first digit may be taken as proof of opposability or at least former opposability. It becomes necessary then, to distinguish clearly between "opposability" and "divergence" of the first digit, as for an intelligent discussion, one should understand clearly what is meant by "opposability." As applied to arboreal adaptation opposability can imply but one condition, *viz.*, a modification which gives the power to grasp or hold, by opposing the first digit to the others, and this is always accompanied by a special and distinctive arrangement and development of the digital muscles. Opposability, it is true, is usually accompanied by a complete divergence of the opposing digit,[6] but divergence, in all stages, is frequently observed where there is no other evidence of opposability. Moreover, examples of divergence without opposability are found most frequently in the older Eocene representatives of almost all the orders of mammals in which the feet are known, while true opposability has not

[6] An exception to this is seen in some of the phalanges in which the first metacarpal is closely appressed to the second, but the toe is opposable and divergent in its phalangeal portion.

been found in any forms of older age than the middle Eocene; and here it is known only in species of a single order. These facts, together with the absence of opposability in tree-living rodents and insectivores, as already pointed out, would in themselves suggest that this condition of opposability is relatively modern in development, or at least not primitive; and in further support of this view it may be noted that in those orders in which opposability has been developed and retained, it is always most advanced in those species which are in other respects notably specialized. Thus, in the Primates, opposability, especially in the hind feet, is found best developed in the heavier, long-limbed monkeys and apes. It has reached its greatest perfection in the hand of man, although doubtless the higher stages of perfection of this function were accomplished after man, formerly arboreal, had finally taken to a terrestrial habitat. Contrary to what one might expect, if opposability were a primitive condition, in the little marmosets of South America, which among living Primates are considered a rather primitive and generalized group, there is, as already stated, not the slightest approach to opposability of the pollex, which is long and functional and it is only moderately developed in the hallux. Yet these little animals are as strictly arboreal in habits as any group of the order. If opposability of the first digit is a primitive condition, then why is it so poorly developed in this particular group while so well developed and perfected in the more highly specialized members of the order? Granting that all Primates began their career in an arboreal habitat, it seems to me a more logical conclusion that the little light-bodied marmosets have never developed opposability, finding the primitive sharp claws sufficiently effective for clinging to the bark of trees, while the heavier-bodied forms, or those species which early formed the habit of swinging from limb to limb as a method of progression through the trees, very quickly took advantage of the *primitively divergent* first digit to develop opposability. This function once developed to a degree where the grasp became firm, the claws would no longer act as formerly, and the constant pressure thus transferred to the palmar side of the toe, or finger tips, would soon modify them into the "nail," so characteristic of the Primates.

If by the term "primitive opposability" is meant simple divergence of the first digit, it seems to me purely assumption, based on no convincing evidence, to interpret this condition as denoting an arboreal habitat. This interpretation, moreover, seems not warranted without the most positive proof, especially when such a foot as that of *Claenodon*, for example, or any other primitive mammalian foot of the basal Eocene types shows no evidence of true opposability and, moreover, could be derived, with such comparatively slight changes, directly from the primitive reptilian type of foot. In fact it is but a short step in mechanical adaptation from the reptilian state to the type of foot of which *Claenodon* is a somewhat advanced example. On examining a foot of *Sphenodon* or other reptile of generalized type, the distinctly reptilian characteristics seem to be these: Foot completely plantigrade; metapodials all more or less divergent, permitting free spreading of the digits; metapodials shorter than phalangeal portion of the digit; first digit shortest; fourth digit longest of the series; phalangeal formula digits I to V, 2, 3, 4, 5, and 3 or 4, respectively. Comparing now the type of foot under discussion. The following seem to be the principal modifications which mark its advance over the reptilian type: The foot has remained plantigrade with the metapodials shorter than the phalangeal portion of the digit and with digit IV, though relatively shortened, still longest of the series; digits II to V are drawn somewhat more closely together, but are still capable of considerable spreading; the first digit, retaining more or less its original reptilian position, is left more divergent than the others; and the phalanges of the median two digits are reduced to the mammalian number, three in each digit.

These simple modifications seem to be purely mechanical adaptations brought about in changing from the reptilian crawling manner of locomotion, to the mammalian walking gait, and each modification may be readily explained on this hypothesis. In the normal position a reptile or batrachian carries the feet well out from the body, with the toes directed more or less outward in such a manner that the short first digit is directed first inward then forward toward the end of the stride, the heel re-

maining on the ground, so that normally the weight of the body is not brought fully on the ends of any of the metapodials. In terrestrial mammals, even of the most primitive plantigrade type, the feet are brought more under the body in walking, the radius and tibia, respectively, are brought to the inside, the first digit pointing constantly inward and the others more or less directly forward. The result of this modification would be to bring the weight of the body more exactly on the ends of the median toes, especially at the finish of the stride at which time the heel is raised clear of the ground. This would have a tendency to stiffen the wrist and ankle joints, through a closer articulation of their bony elements, to bring the divergent metapodials more closely together, and to shorten the median pair of toes. This change in position of the feet and consequent change of the manner in which the toes are applied to the ground in walking may have been the primary cause of the reduction in phalanges of digits III and IV, and would quite satisfactorily account for the divergence of the first digit so frequently found in the primitive mammalian foot. It will be especially noted that the first digit is shortest, and in the mammalian position of the foot is so placed as to take no considerable part in the function of walking, hence it has been least modified and soonest lost in terrestrial forms which acquired a digitigrade gait.

It is plainly obvious that, from a central type of primitive mammalian foot similar to that just described, in which the first digit is unreduced, it is but a short step to true opposability. The divergent first digit could readily be converted into a grasping organ, and the modification to opposability doubtless was soon accomplished by those forms which early adopted an arboreal habitat. But among ground-living forms, in the other direction, it was an equally short step to the strictly terrestrial digitigrade type, in which the first digit was gradually atrophied, as it became functionless through being raised from the ground, and in many species has been lost altogether. In the process of development of the digitigrade type the functional metapodials are brought closely together and have become relatively lengthened while the phalangeal portion of these digits becomes shortened. It is through these stages of development that have

come directly the modern ungulate types of feet. Still another type developed from the primitive terrestrial mammalian foot, or possibly directly from the reptilian stage, is that type of which the short-toed amblypod and probosicidian feet are examples. In these forms the toes remain more or less spreading, and all, including the first when present, function in bearing the weight of the body. In this type of foot the heel may become raised from the ground as in the digitigrade type, but this modification is always accompanied by the development of a pad so that this portion of the foot still functions in carrying its share of the body-weight as in the plantigrade type. It may be further assumed that the various aquatic types of feet are directly derivable from some such foot as that of *Claenodon*.

It would thus seem that the primitive mammalian foot, of the central group, must have been primarily terrestrial, and from this generalized type of foot, with *divergent* but not *primarily* opposable first digit, have been developed all sorts of modifications of foot structure, each adaptable to the kind of environment chosen, and that divergence of the first digit is primarily an inheritance from the primitive reptilian condition, and can not be considered as in any way supporting the hypothesis of an arboreal ancestry of the Mammalia. It is likewise quite as apparent, it seems to me, that true opposability of the first digit wherever found should be considered a direct specialization of the primitive condition brought about by a mechanical adaptation to a peculiar (arboreal) life habit.

This viewpoint is certainly not weakened and seems to be strengthened by the difference in type of modification observed in the hind foot of marsupials as compared with that of the Primates. In the former, as observed by Huxley, opposability of the first digit is accompanied with enlargement of the fourth digit, and reduction and syndactylism of the second and third digits, while in the latter there is no approach to either of these modifications. This difference seems to be fundamental, and suggests that the marsupials took to tree-living habits at a somewhat earlier stage of development while the fourth digit was yet considerably longer than the others, and for that reason more directly opposed by the first digit.

INTERFEROMETRY.—*The use of the interferometer in the measurement of small dilatations or differential dilatations.* C. G. PETERS, Bureau of Standards. (Communicated by S. W. Stratton.)

The dilatometer originated by Fizeau and further developed by other investigators consists of two interferometer plates separated by three pins of slightly different length, made in the form of a tripod or ring. When this interferometer is illuminated and viewed in the proper manner, curved interference fringes appear. The change in the length of the pins is determined from the displacement of these fringes past a reference mark, which is usually ruled in the center of the lower surface of the upper mirror. The quantity that is actually determined, however, is the change in the distance between the two plates at the reference mark, which is equal to the change in length of the pins, if their behavior is identical, or nearly equal to their mean, but not their individual change in length when they behave differently. In fact, two of the pins may expand while one contracts, or the three pins may change in such a manner as to cause the fringes to rotate through 360° without causing any displacement of the fringes past the reference mark. The unequal variations in the length of the pins cause the direction and angle of the wedge between the plates to change, which in turn changes the direction and width of the fringes. This was slightly noticeable in our work with three pins of steel, quartz, brass, or copper, and quite pronounced with glass near 600° C. H. G. Dorsey[1] observed this fact in his work on the thermal expansion of zinc.

The exact change in length of each individual pin can be determined from the change in the order of interference (the number of light waves) between the plates at the points of contact of the pins. This was accomplished without changing the Fizeau apparatus in any way except to make the reference marks at these points of contact. The pins were made in the form of cones, about 4 mm. across the base and 10 mm. long. Three

[1] Phys. Rev. 26: 5. 1908.

conical holes, 0.5 mm. in diameter, 0.2 mm. deep, and about 15 mm. apart, were drilled in the lower surface of the cover plate. The pins were placed between the interferometer plates so that the points of the cones fitted into the holes in the cover plate. These holes kept the pins in their triangular positions, stopped any creep of the cover plate and served as reference marks in the determination of the change in length of the pins. The fringes were viewed with a Pulfrich[2] apparatus. With this instrument the part of the interference pattern which is obscured by the pins can be easily bridged with the crosswires.

Let the lengths of the three pins be designated as A, B, C, the wave length of the light as λ, and the order of interference between the plates at each reference mark as a_1, b_1, c_1, under one condition, and a_2, b_2, c_2, under a second condition. The absolute changes in the lengths of the pins are then:

$$\Delta A = \frac{\lambda}{2}(a_2 - a_1) \qquad (1)$$

$$\Delta B = \frac{\lambda}{2}(b_2 - b_1) \qquad (2)$$

$$\Delta C = \frac{\lambda}{2}(c_2 - c_1) \qquad (3)$$

The changes in order $(a_2 - a_1)$, etc., can be obtained, from the displacement of the fringes past the reference marks or from the determination of the whole orders a_1, a_2, b_1, etc., by using the approximate length of the pins and the measured fractional orders due to several wave lengths, by the method described by Meggers,[3] which holds as well for straight fringes as for Haidinger's rings.

The relative or differential changes in the length of the pins can be determined from the differences in order at the reference marks. The quantity $(a_1 - b_1)$ is the difference in the orders between the plates at A and B under the first condition, and $(a_2 - b_2)$ is the difference in the orders at A and B under the second condition. These quantities are determined from the whole number of fringes and the measured fractions, between

[2] Zeitschr für Inst. 18: 261. 1898.
[3] Bull. Bur. Stand. 12: 203. 1915–16.

the reference marks at A and B. The change in these differences of order is then

$$(a_2 - b_2) - (a_1 - b_1)$$

and the relative change in the length of A and B is

$$\Delta A - \Delta B = \frac{\lambda}{2}[(a_2 - b_2) - (a_1 - b_1)] \qquad (4)$$

Similarly, the relative change in the length of A and C is

$$\Delta A - \Delta C = \frac{\lambda}{2}[(a_2 - c_2) - (a_1 - c_1)]. \qquad (5)$$

If ΔA is known or has been obtained from the determination of $(a_2 - a_1)$, equation (1), the value of B and C can be computed from these relations.

The arrangement of the apparatus just described was used at the Bureau of Standards to measure the differences in the thermal expansion of steel samples, and to determine the thermal expansions of steel, copper and brass simultaneously in the temperature interval of 0° to 100° C. It is now being used in the investigation of dental materials to determine the thermal expansion and the change in length while setting. The results of these investigations will be published in the Bulletin of the Bureau of Standards. This form of the apparatus is very easily made and adjusted. The pins can be cut out in a few minutes and their size measured with sufficient accuracy with a micrometer. They can be of almost any shape as long as the base is plane and the top is brought to a conical point. The reference marks can be drilled in the cover plate in a very short time and it is not at all necessary to know the distances between them. The fact that only a small area of the plates close to the reference marks and not a portion of the plates removed from the samples is used in making the measurements of the absolute change in length of the pins, eliminates the necessity of having the plates perfectly flat. They may be slightly concave or convex. The same thing holds for the relative determinations. The interference fringes denote the difference in separation of the plates at the reference marks, even though the intervening surfaces deviate slightly from true planes.

By using the Fizeau apparatus in the manner described in this paper the absolute change of length of one, two, or three small pins can be determined during one experiment. The exact change in each pin is determined and not the mean change of the three pins. The unequal change of similar pins is not important in most practical tests, but where precision is desired it is quite annoying. The differential changes in length of three pins can also be determined without knowing the absolute change of any of them.

As it is rather difficult to watch the displacement of the fringes past the three reference marks simultaneously, it is better to determine the absolute change in length of one pin by equation (1) and compute the values for the other two pins with equations (4) and (5). The results in either case are exactly the same because they depend upon the same measurements of the fractional orders. The accuracy of these results is limited only by the accuracy with which the fractional orders are determined.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

BOTANY.—*A botanical trip to Mexico.* A. S. HITCHCOCK. Sci. Monthly **8**: 129–145, 216–338, pls. 34, maps 6. February, March, 1919.

An account is given of a trip made in 1910 for the purpose of studying and collecting grasses. A map showing the itinerary indicates that all the states north of the isthmus of Tehuantepec were visited except Sinaloa, Tlaxcala, and the territory of Tepic. There is a discussion of the topography (illustrated by a map), the rainfall (with a table and map showing the annual rainfall at representative stations, a map showing isohyets, a series of maps showing the annual rainfall by months), and the temperature. An account is given of the floral regions, the range conditions, and the forage crops.

Especial attention is given to the distribution of the grasses in relation to the floral regions, of which the most important are the eastern Coastal Plain, the western Coastal Plain, the Plateau, the slope from the Plateau to the Coastal Plain, the high mountains, and the ponds and marshes.

Orizaba was ascended to nearly 18,000 feet, Popocatepetl to snowline (about 15,000 feet), and Nevada de Colima to the summit (14,370 feet).

A. S. H.

ECONOMICS.—*Potato flour and potato bread.* J. A. LECLERC. The Potato Magazine. January and February, 1919.

This article compares the composition of potato and wheat flours and of breads made with a combination of 20 per cent of potato flour and 80 per cent wheat flour. It also shows how many pounds of the various food constituents of potato, potato flour, and of wheat flour can be obtained for one dollar with varying prices for these products. The amount of food constituents obtained from one acre of land grown to potatoes and to wheat is also given. Bread made with the use of potato flour as a part substitute is appreciably richer in mineral constituents than is white bread, but somewhat poorer in fat and protein.

With flour at $12.80 per barrel and potatoes at $1.75 per bushel, flour is a cheaper food than potatoes, and will furnish considerably more dry matter, protein, fat, and starch, and heat units for $1.00. On the other hand potatoes will furnish four times as much mineral ingredients as will the white flour for the same money. On the basis of average yields of 100 bushels of potatoes and 14 bushels of wheat per acre, one acre of land planted to potatoes will produce more food than in the form of wheat to the following extent: 36 lbs. of mineral constituents or a gain of 560 per cent; 28 lbs. of protein, a gain of 37 per cent; 437 lbs. of starch, a gain of 87 per cent; 848,000 calories, a gain of 76 per cent.

J. A. LEC.

TECHNOLOGY.—*The microstructural features of "flaky" steel.* HENRY S. RAWDON. Bull. Amer. Inst. Mining Eng. No. 146, p. 183. 1919.

One of the most vital problems in the manufacture of steel is the occurrence of defects designated as "flakes." These spots are usually revealed, if present in steel, when the tension specimen is taken so that it represents the mechanical properties of the material in a direction at right angles to the direction of forging. Flakes constitute one of the most serious problems met with in the manufacture of large caliber guns. Their occurrence in chrome nickel steels of the type used for air-plane crank-shafts is also a serious problem. To the unaided eye, a "flake" appears in the fracture of a freshly broken test specimen as a silvery white, very coarsely crystalline area surrounded by metal having the normal appearance. Such areas vary in size from minute spots to those 1 cm. or more in diameter. Microscopic examination of numerous specimens showed that the coarsely crystalline appearance is a surface configuration only. The "flake" has no depth; the metal in such areas is refined to the same degree as throughout the body of the piece. Within the mass of the steel, flakes exist as intercrystalline discontinuities. They may be located by means of X-ray examinations and when the specimen is broken along the line of such discontinuities a typical flake is revealed. The discontinuities in the metal often enclose inclusions of a nonmetallic nature in the form of very thin films. This is not always the case, however, and while flakes appear to occur most readily in "dirty" steel, it is not safe to assume that the presence of inclusions necessitates the presence of flakes.

H. S. R.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY OF WASHINGTON

The 594th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, March 22, 1919, called to order at 8:00 p.m. by Vice-President N. HOLLISTER; 33 persons present.

The regular program was as follows:

J. W. GIDLEY: *Notice of a large canid from the Cumberland Cave deposits.* Mr. Gidley briefly referred to the discovery of these deposits in western Maryland through the digging of a railroad cut and to his explorations of them. He then described the remains of a large doglike animal found in them by him. He pointed out its relationships to modern wolves, coyotes, and to the doglike remains in the asphalt deposits of southern California.

A. C. BAKER: *Intermediates in the Aphididae and their relation to alternate hosts.* Rearing experiments have shown the existence of adult intermediate forms in all species studied carefully by the writer. These forms show modifications in nearly all important structural characters. They occur between the forms on one host and between the forms on a primary and a secondary host. Thus they indicate the ultimate division of species, such as the latter, into two. In fact, almost, this occurred in the experiments. Host races were developed with such species as *Aphis rumicis*. These races differed in structure, after 50 generations or more, and individuals of them nearly all died when transferred to the host of their ancestors.

Our American species of *Anoecia* on *Cornus* compared with specimens from different parts of Europe (from H. SCHOUTEDEN, ALBERT TULLGREN, and others) differs in sensory organs. Our species, as reared, never developed the European characters. In most cases it became modified in the opposite direction. Races were developed which live the year round on grass roots, laying their winter eggs there. These forms differed very distinctly in structure from those including *Cornus* in their host cycle. In some sections of the country these, or similar races, seem to be settled as definite species with definite structure and definite reproductive and host habits. In our classifica-

tions we have no names for these potential species. In some cases it is necessary to rear very large numbers to determine the connection between forms existing in nature and it would seem advisable to have some designation for such groups of individuals.

The family seems to be in a more or less pliable state and these cases which we are able to observe may indicate the method by which different forms have come into existence and possibly some of the methods by which species fixation has taken place.

Discussion by DR. L. O. HOWARD and S. A. ROHWER.

R. H. TRUE: *Bernardin de Saint-Pierre as a plant ecologist.* The author of "Paul and Virginia" wrote a three-volumed book, entitled "Studies of Nature," intended to prove to a world that was lapsing into atheism that a beneficent Providence rules the affairs of men and of Nature. In this effort he studies the relations of plants to the main factors of their environment. He groups plants into two great classes, those enjoying a limited water supply, the mountain plants, and those whose supply is not limited, those of the plain, marsh, and riversides. Devices for collecting or shedding water are traced in foliage and stem. Flowers are dealt with in relation to light and heat, seeds and fruits to means of securing distribution. Many practical relations are discussed such as forest planting to increase rainfall, and the relation of stock grazing to forest injury. He deals with his evidence in a teleological spirit, oftentimes proving too much, but writing always with vivacity, clearness, and charm. As "nature writing," his work is worthy of attention from this later generation. It should not be neglected by plant ecologists and naturalists.

M. W. LYON, JR., *Recording Secretary.*

GEOLOGICAL SOCIETY OF WASHINGTON

The 330th meeting was held at the Cosmos Club, Wednesday evening, January 22, 1919, President ULRICH presiding, and 60 persons present.

The meeting was a memorial to GROVE KARL GILBERT. After introductory remarks by President ULRICH, the following program was presented:

Biographical outline.....W. C. MENDENHALL
Gilbert in his administrative relations.....C. D. WALCOTT
(read by E. O. ULRICH)
Gilbert as the student and expounder of geologic structure
.....F. L. RANSOME
Gilbert the physiographer and explorer.....H. E. GREGORY
Gilbert the glaciologist.....W. C. ALDEN
Gilbert the physicist and mathematician.....R. S. WOODWARD
Gilbert the topographer..J. H. RENSHAWE (read by E. O. ULRICH)
Gilbert as a man.....C. HART MERRIAM
Personal reminiscences....C. D. WHITE, H. C. RIZER, and J. S. DILLER

The 331st meeting of the society was held at the Cosmos Club on Wednesday evening, February 12, 1919, President E. O. ULRICH, presiding, and 74 persons present.

INFORMAL COMMUNICATIONS

T. W. VAUGHN: *Correlation of Tertiary formations on the perimeter of the Carribean Sea.*

R. S. BASSLER: *Quartz from Waynesboro formation crystallizing with three-faced terminal pyramid and used for correlation.*

REGULAR PROGRAM

RALPH ARNOLD: *The economic value of paleontology.*

E. W. SHAW: *Stratigraphy of the Gulf Coastal Plain as related to salt domes.*

This paper being in a way introductory to the following paper on the program has to do primarily with those features of the stratigraphy that are of principal interest in the study of salt domes. The more significant of these features relate to the age and thickness of the formations, and to the rigidity, chemical nature, and specific gravity of the materials composing them.

As is well known the formations are of Mesozoic and Cenozoic age and with the exception of the Jurassic most of the main divisions of these eras are known to be represented by deposits. Perhaps the divisions of the Cenozoic are more fully represented than those of the Mesozoic.

The aggregate thickness of the Cenozoic is commonly between 5000 and 7000 feet, the Eocene being 2500 to 3000, Oligocene and Miocene 2000 to 2500, and the Pliocene and Quaternary from 1000 to 3000. The upper Cretaceous seems to have the thickness ranging from 1500 to 2500 and the lower Cretaceous, where present, from a feather edge to about a thousand feet. Over a large area in coastal Louisiana and Texas the aggregate thickness of the various Cretaceous, Tertiary, and Quaternary formations probably ranges between 8000 and 12,000 feet and may average about 10,000 feet.

Apparently most of formations thicken somewhat toward the coast but the average or aggregate amount of thickening is unknown. To the east there is a notable thinning and rise of certain formations at least; beds lying at a depth of 2000 feet near Mobile lie at far greater depths two hundred miles to the west and a similar distance from the coast.

The age and nature of the materials underlying the Cretaceous along the Gulf Coast can only be conjectured. Knowledge concerning these materials and in particular as to whether or not they include beds or masses of salt and intrusions of igneous rock might be of considerable assistance in solving the salt dome problem. In central and western Texas the Triassic and Permian beds are many hundred feet thick and are salt bearing but they dip to the west and without reversal can not be present in Louisiana. Neither this nor any other known fact proves that there are no Permian or Triassic salt beds under Louisiana, but on the other hand the only reason for suspecting that they are present is the conclusion that the salt, gypsum, dolomite, sulphur, and other mineral matter in the salt dome came from below and the fact that such mineral matter is perhaps more common in the Permian and Tri-

assic than in any other group of beds. The copper and other metallic minerals, small quantities of which have been reported at one or two places, harmonize with the hypothesis.

The lithologic features of the Cretaceous and Tertiary that are of special interest in the salt-dome problem are the generally more clayey and apparently also more carbonaceous constitution of the material west of the Mississippi as compared with that to the east. Apparently the salt domes occur where the beds are thicker, softer, and more carbonaceous, and the writer suspects that there is some relation between these characteristics of the region and the domes. There are, of course, a good many more or less thoroughly indurated beds including chalk and limestone west of the Mississippi, particularly in the older formations, but the mass of Mesozoic and Cenozoic materials as a whole seems to be of a conspicuously yielding nature.

The great thickness and the low degree of rigidity are apparently related to a westward littoral current which, though not strong enough to carry sand except along the strand, has for ages carried very fine-grained and clayey material westward from the mouths of the Mississippi and other ancestral and present-day rivers discharging from the central and eastern portion of the Gulf embayment. The most striking general feature of the samples that I collected on the Fish Hawk expedition, a few years ago, is the contrast between the dark and clayey sea-bottom material west of the Mississippi and the lighter-colored and coarser-grained material to the east.

Since the deposits are mainly unconsolidated and many layers are plastic it seems presumable that in the process of intrusion, differences in specific gravity between intruding and intended materials will control to a more or less notable degree the form of the intrusion. For example it seems quite possible, if not probable, that if a rising mass of salt or one of molten rock comes to a position where the overlying material weighs less per cubic foot than the rising mass, the mass may cease rising and may even "mushroom," whereas if the overburden were heavier the intrusion might continue to rise and might even develop into an extrusion. The clay and incoherent sand of the gulf coast have an average specific gravity including the water in their pores of about two (probably somewhat less than two) and therefore are a little lighter than salt and much lighter than igneous rock. Hence the absence of igneous rock at the surface cannot be taken as an indication that the salt domes have not formed over igneous plugs.

Another way that differential specific gravity may play a part in the growth of salt domes is based on the fact that the hydrostatic head at any point underground is only about half the weight of overlying deposits. Assume a bed of salt with a perfectly smooth top lying at a depth of 10,000 feet and upon this salt a bed of sand with interstices filled with water which, by way of connecting interstices, forms a continuous column up to the surface of ground water. Where the grains of sand rest upon it the salt supports a pressure about 8000

pounds to the square inch. Where the water rests upon it the pressure is only about half as great. Salt being somewhat plastic the difference in pressure would no doubt cause the sand grains to sink into the salt and the salt to rise between sand grains until friction put an end to the adjusting process, which might be in a fraction of an inch.

Now suppose a rising igneous plug approaches the salt bed and raises the temperature until, with whatever aid may be rendered by the ever-present water, it melts the salt. The process outlined above would then proceed to a much greater extent, the salt rising like so much water until the supply near enough the plug to be melted was exhausted. Apparently the process might involve the pushing aside of a large body of sand and other materials and the development of a considerable mass of salt, accompanied by unusual secondary deposits due to the unusually high temperatures.

G. S. ROGERS: *Origin of the salt domes of the Gulf Coast.* The origin of the great plugs of salt that occur here and there beneath the Coastal Plain of Texas and Louisiana is an obscure problem which has been a subject of much speculation. The small diameter of these plugs and their great depth (at least 5,400 feet in once case) indicate that they are not original bedded deposits. Nearly all American writers have adopted the view that the salt has been deposited by ascending brines, but the plausibility of this theory is injured by the stupendous quantity of brine involved, for no likely condition has been suggested under which the waters would deposit more than a fraction of their dissolved load.

Although direct evidence of the mode of formation of the salt plugs is scanty, there are several indications that positive tectonic forces have been involved. The plugs are arranged rather regularly along lines that are undoubtedly related to the main structural features of the region. Moreover, the plugs have caused a sharp and very local upthrust or doming of the normally flat-lying sediments, the uplift in some cases amounting to at least 3000 feet. The surface beds may be only slightly disturbed, if at all, but down on the flanks of the salt mass dips of 60° or more are common and in some cases formations have been thrust clear through the beds that normally overlie them. Still more direct evidence is afforded by the structure of the salt itself; as seen in the mines the salt contains dark streaks which, though commonly standing almost vertical, are in places thrown into intricate folds which bear an extraordinary resemblance to the flow structure of ancient rocks. The common elongation of the salt crystals in a vertical direction and the rough horizontal cleavage of the salt also suggest vertical movement.

Laboratory experiments have shown that salt under differential pressure behaves as a highly plastic substance; that its plasticity is increased by heat; and that if shattered it is easily welded by pressure. In view of the field evidence cited, the writer believes that the salt plugs are offshoots of deeply buried bedded deposits which have been subjected to great pressure or thrust, and have been partially squeezed upward in a semiplastic condition along lines of weakness. As the

region lies along a heavily loaded sea coast, the nature of the lateral thrust is not difficult to understand. The fact that the surface beds are undisturbed, except immediately around the salt plugs, is explained by the nature of the section—a series of indurated and rigid formations overlain by a great thickness of relatively yielding and plastic sediments. Indirect evidence of the origin of the plugs is also afforded by their identity in structure and composition with the European salt stocks, the tectonic origin of which is declared to be unmistakable.

The 332nd meeting of the Society was held in the Cosmos Club Wednesday evening, March 12, 1919, President ULRICH presiding and 46 persons present.

INFORMAL COMMUNICATIONS

G. W. STOSE: *Travertine from Rock Creek Park, District of Columbia.* Travertine occurring in a granite country would seem to be unusual, but travertine has recently been found on the granite and schist in Rock Creek Park, near Blagden Mill road. This deposit of aragonite travertine occurs at the mouth of an apparently large spring which empties into Rock Creek. On investigation the spring proved to be an overflow from a nearby city reservoir. It seems therefore that the travertine deposit came from lime dissolved out of the cement in the masonry of this reservoir and its conduit.

In discussing Mr. Stose's paper, R. S. BASSLER, of the National Museum, called attention to the deposit of calcareous stalactites in a culvert under the aqueduct along Potomac River in the District of Columbia. These stalactites are derived from lime used in the masonry of the aqueduct, and a new crop is found on each annual visit of a class in geology.

R. B. SOSMAN: *The temperature inversions in the fumaroles of the Valley of Ten Thousand Smokes, Alaska Peninsula.* The peculiar inversion of temperatures in the fumaroles of the Valley, which was discovered in 1918 and reported by Prof. R. F. GRIGGS in his lecture before the Washington Academy of Sciences on February 18, 1919, and which seemed at first the most puzzling feature of the fumaroles, may find explanation in the "velocity cooling" which is known to occur in a jet of gas issuing from an orifice. It has been observed experimentally by Joule and Thomson[1] and by Bradley and Hale[2] in high-pressure air jets, and is discussed by S. A. Moss[3] in connection with experiments on steam flowing from orifices. The cooling effect is due to the conversion of heat energy into translational kinetic energy, which is subsequently converted back into heat when the high-velocity jet of steam is checked. We have here the possibility that the apparent temperature of a jet, as measured by a thermometer, will show variations with the shape and size of the thermometer.

[1] JOULE and THOMSON. Phil. Mag. (4) 4: 491. 1852.

[2] BRADLEY, W. P., and HALE, C. F. Phys. Rev. 29: 266. 1909.

[3] MOSS, S. A. Trans. Amer. Soc. Mech. Eng. 38: 766. 1916.

The temperature differences found by measurements at different levels in the fumaroles of the Valley are, however, on a larger scale than any that are ordinarily observable experimentally, and it is still possible that some other factor may be active in addition to the velocity cooling.

T. W. VAUGHN: *Note on Eocene corals from Peru and on other fossils from Haiti and Trinidad.*

REGULAR PROGRAM

F. E. MATTHES: *Relief shading of topographic maps.* The most difficult thing which cartographers and topographers have to deal with is representing the vertical element in the delineation of land features. This delineation can be done in several ways as by hachuring, contouring, and by shading. Hachuring has been developed to an art in Europe. It requires a draftsman with a steady nerve and hand, and the reproduction of his work by expert engravers. The art had reached fine execution by 1815, yet in Europe, long ago, hachuring was replaced by shading. The same effect is obtained with perhaps one-twentieth the cost. Shading represents land forms perhaps more adequately than hachuring and can be used to better advantage and more generally than hachuring.

For the last three decades in the United States we have devoted our energy almost exclusively to contouring. No country has done better, but we have used contours where their use was at a disadvantage. Delineation of land forms has been attempted also by hypometric tints but these must be based primarily on contour work. It is a good practice for hachuring and shading to be done as if a relief model were hung vertically on a wall and illuminated above and to the left. In experimental work done by J. H. Renshawe, of the U. S. Geological Survey, this lighting element has been employed but Mr. Renshawe has developed one method different from that of European topographers, in that dark shading is used to express the lowest altitude of river areas, whereas in European maps lowlands are lighter and high plateaus are dark. On shaded maps made recently by the U. S. Geological Survey, high plateaus are given a light shading and flat areas close to sea level are given a deep shading. This obviates confusion found on European maps in which both the mountain tops and the valley bottoms are given the same high light.

O. E. MEINZER: *Quantitative methods for estimating ground-water supplies.* This paper relates only to *ground water*, or *phreatic water*—that is, water in the zone of saturation. It is not concerned with the subsurface water that occurs above the water table. It relates not to the quantities of water stored in the earth but to the rate of replenishment of the ground-water supply, on which conservation developments must be based.

Four principal groups of methods are used to determine the annual recharge or the "safe yield" of ground water: the Intake, Discharge, Water-table, and Underflow methods. The first of these consists in

measuring the quantity of surface water that seeps into the earth and percolates into the zone of saturation; the second in measuring the ground water that is discharged through springs, or by evaporation from soil and plants; the third in observing the fluctuations in the water table, which represents filling or emptying of the ground-water reservoir; the fourth, like the gaging of surface streams, in measuring the flow of ground water at selected cross-sections.

Discharge methods comprise two very different kinds of methods: (1) the differentiation of ground-water run-off from direct run-off through study of hydrographs, etc., and (2) the mapping of areas that discharge ground water by evaporation and transpiration, and experiments to determine rates of discharge under specific conditions of soil, vegetation and depth to water table. In arid regions plants of certain species habitually utilize water from the zone of saturation. For such plants the name *phreatophyte*, meaning a "well plant," has been proposed.

The water-table methods are best adapted to regions, such as California, which have well-defined rainy and dry seasons. The average annual increment to the ground-water supply can be computed by multiplying the average rise of the water table in the rainy season by the percentage of available pore space, and multiplying this product by the area of the water table of the given aquifer. The most uncertain factor is the percentage of available pore space, or *specific yield*, which is not the same as the porosity of the rock, because when the water table descends some of the water is held against the pull of gravity by the molecular attraction of the rock. Tests of specific yield have been made (1) by laboratory experiments; (2) by examination of samples of material which is above the water table but which in the high-water stage was in the zone of saturation; and (3) by making heavy pumping tests and ascertaining the total pumpage and the total volume of sediments drained thereby.

The two lines along which additional research are most needed relate to the habits of phreatophytes and their rates of transpiration and to the specific yields of different kinds of sediments. A very fortunate feature of the quantitative work is that the three principal methods—intake, discharge, and water-table—are entirely independent of each other and can be used as checks upon one another.

The 333rd meeting of the Society was held at the Cosmos Club on Wednesday evening, March 26, 1919, President ULRICH presiding, and 48 persons present.

INFORMAL COMMUNICATIONS

F. L. HESS: *Phenocrysts in granitic intrusions.* Deposits of rare metals are commonly connected with granites and are usually in the outer parts of granitic intrusions, and it thus happens that many of the deposits are accompanied by extraordinary forms of the granite. Close to the cobalt deposits on Blackbird Creek in Lemhi County, Idaho, a remarkable porphyritic granite is found on Big and Napias Creeks. The

phenocrysts are speroidal or elliptical and as much as three inches long by two inches in diameter. They weather out and look like rounded pebbles. The main intrusion is exposed for about three miles along the creek but it is not known at what angle the creek cuts the dike. Smaller dikes are from fifty to several hundred feet broad and all are crushed to gneisses along their sides.

D. E. WINCHESTER: *Contorted bituminous shale of Green River formation in Northwestern Colorado.* In the upper part of the oil shale series of northwestern Colorado there is a zone of rich black bituminous shale which is everywhere contorted showing on its weathered surface minute folding and faulting. This shale which has been observed over a wide area is overlain and underlain by beds of laminated and uncontorted shale and sandstone. The bituminous shale itself contains a large amount of microscopic vegetable material, including algae, etc., and this may furnish a clue as to the reason for its contorted condition. The region is one in which there is practically no faulting, and beds dipping as much as 15° are the exception rather than the rule. It is concluded that the twisting of the laminae occurred before the bituminous shale was completely solidified and that the beds containing the great amount of vegetable matter were least competent and may therefore have taken up any movements which may have occurred in the region. Specimens of thinly laminated shale rich in organic matter but occurring at a horizon 300–500 feet below the black contorted beds, show intricate folding and minute faulting.

Discussion; E. O. ULRICH: The same contorted condition of thin beds can be seen in mud laid down on tidal flats and then slumped by tidal undercutting. It is shown also in West Canada Creek at Trenton Falls, New York, where the limestone, once a limy mud, has these features. C. D. WHITE: Green River beds essentially horizontal are a good place to see thin contorted strata. The contorted beds are buried beneath shale and sandstone. It would seem that the organic beds between sandstones must have been slimy mud a long time after burial and even if somewhat hardened must have been the easiest zone for slipping. They doubtless were somewhat solidified when the crumbling took place else there would be no faulting. Possibly the shale exhibited by Winchester was deeply buried and the contortion is due to movement along the oil shales after they were partly solidified. The overlying and underlying formations have a somewhat reinforced structure and slight jars or lesser earth movements would be taken up by oil shale beds which are rich in vegetal matter. Similar structure is found in the Elkhorn coal on Marrowbone Creek in eastern Kentucky, where the upper part of the coal bed moved on the lower part. W. C. ALDEN: This kind of structure is common in glacial lake beds where we find zones a few inches thick highly contorted, while above and below are beds clearly and beautifully laminated, which show no disturbance. It is suggested that the contortion may be due to freezing before the superincumbent layers were deposited. G. H. ASHLEY: In northern Indiana the plankton found in the small lakes resembles in structure the

shale shown by Winchester. This jelly-like material moves with the movement of the water. Storms move the water-weeds and the light floating jelly-like stuff may be moved at the same time, and rumpled.

REGULAR PROGRAM

ROBERT B. SOSMAN: *Note on volcanic explosions.* The usual conception of a volcanic explosion is that of the release of a store of pent-up energy which has been held in a confined space by external pressure. The idea takes two forms: (1) The "boiler explosion," in which the pressure has been raised by heat to a value which exceeds the breaking strength of the containing rocks; or, (2) the "geyser eruption," in which a metastable configuration of the materials of the volcano has been disturbed and a violent reaction has begun. In either case, the conception is that of a system in rapid reaction in an effort to reach equilibrium, following some change in external conditions.

An experiment by the speaker, made several years ago, showed that finely divided alumina, which is well known to be very hygroscopic, could be superheated in an open electric furnace and then be "exploded" by a mechanical disturbance. The phenomenon is strikingly analogous to the dust explosions of Lassen Peak and Mont Pelée.

The steam boiler and the geyser may be called "explosive systems." Another class of explosions results from the initiation of chemical reactions in "explosive mixtures," such as gunpowder, or a mixture of sulfur and potassium chlorate. It seems unlikely that many volcanic explosions can be of this character, on account of the difficulty of accumulating the necessarily large quantities of substances capable of reacting (such as oxygen and hydrogen), without the dissipation of the energy by continuous quiet reaction, as at Kilauea.

In a third class are the "explosive substances," of which nitroglycerin is the most powerful common representative. These explode by internal disintegration and recombination, and can be "detonated" by methods other than simple rise of temperature. Organic dust (flour, coal) with oxygen and moisture adsorbed on the surfaces of its grains is, to all intents and purposes, a chemical compound and an explosive substance, though of a milder type than the nitro-compounds; and even inorganic dust with adsorbed moisture, such as the alumina in the experiment cited, is, analogously, an explosive. It is suggested that dust explosions of the Peléean type, which are often plainly superficial and not deep-seated, are true explosions, possibly set off by mechanical disturbances. The same may be true of Vulcanian and Plinian explosions, the explosive in these cases being a metastable liquid silicate or a mixture of liquid and solid silicates, brought into its metastable condition by a gradual rise of temperature or by the gradual accumulation of water or magmatic gases, either through distillation or through fractional crystallization. The specific character of the shock necessary to detonate an explosive substance; the limited range of propagation of the explosive wave in a powdered material, as contrasted with the more complete detonation which can be brought about in a continuous

liquid or solid explosive; and the fact that the force of a detonated explosion is often in the direction of the detonating impulse and independent of the configuration of surrounding materials (Pelée, Lassen); are all applicable to the explanation of known phenomena of volcanic explosions.

E. O. ULRICH: *Newly discovered instances of early Paleozoic oscillations.* Anyone who will undertake a comprehensive course of critical and detailed comparison of stratigraphic sections must inevitably reach the conclusion that the old land surface was exceedingly unstable with respect to sea level and subject to oft-repeated differential movements and warping.

At times certain parts were pushed up, while other parts lagged, and yet others sank, actually or but relatively, beneath sea level. In other words, the vertical movements of the lithosphere were differential, and the displacements of the strandline were not erestatic, as taught by Suess, but varied in volume and direction from place to place.

The differential character of the movements of the continental areas with respect to sea level is indicated by abrupt local, or even widely distributed changes in the character of the sediments; by imperfections in the record of marine deposits at one place which are partly and sometimes, perhaps, wholly supplied in the sedimentary record at another place; by the sudden extinction of, say, an Atlantic fauna in a given area by a Gulf of Mexico or an Arctic fauna; and by other more or less competent criteria.

Most convincing evidence of land tilting, with alternating east and west tilts more common than those to the south or north, was brought out by *detailed* comparisons of the sedimentary record on the flanks of old uplifts in interior North America. Particularly illuminating are the facts showing restriction of formations of considerable thickness to one side of such uplifts and similar restriction of other formations to the opposite side. Geographic restriction of deposits, hence also of the seas in which they were laid down, is indicated over and over again on the flanks of the Cincinnati, Nashville, Ozark, Wisconsin, and Adirondacks domes. These domelike areas rarely, if ever, formed islands. As a rule, when they were not completely submerged, they were connected with larger land areas, often probably forming peninsular projections.

Oscillation of land and sea areas was the rule also in the Paleozoic Appalachian Valley. However, the conditions here differed in that the seas were largely confined to subparallel structural troughs. These troughs were not all submerged at the same time; and only very seldom was any one of the five or six troughs submerged throughout its length. As a rule tilting, or differential movements, produced canoe-like depressions which, when they reached depths permitting marine submergence, formed narrow inland bays. These bays were emptied and again filled many times, and each submergence differed more or less in its geographic expression from those preceding it.

The old belief in broad, deep, and long enduring continental seas—seas that began early in the Cambrian and continued spreading wider and wider until well toward the close of the Ordovician—is still held and taught in some of our best universities. But this inexcusable conservatism is possible only by closing our eyes to the overwhelming accumulation of opposing facts. Sooner or later it must be abandoned by all. In its place the more progressive geologists conceive of smaller, very shallow, and frequently shifting bodies of water, of seas, that filled a given basin in one age and were withdrawn in the next, that returned again and again in familiar patterns, though perchance from different quarters, in succeeding geological ages. In short, seas that migrated in and out of the structural basins—sometimes extending far across the continents and at other times limited to much smaller areas—whenever and wherever a formation of the lithosphere demanded corresponding readjustment of land and marine areas. These adjustments were always marked in the stratigraphic record by recognizable signs.

Each year's field work is disclosing evidence of Paleozoic oscillations previously unknown; and some of them occur in what had seemed altogether unlikely places. The purpose of my paper is to discuss a half dozen or so of the more striking instances that have been discovered since the publication of the "Revision." The first of these is found in central Pennsylvania, the second and third in east Tennessee, the fourth in northeastern Alabama, the fifth in Wisconsin, the sixth in the Mississippi Valley. In the last two the formations lie practically horizontal, in the others they are folded in the usual Appalachian manner.

R. W. STONE, *Secretary.*

SCIENTIFIC NOTES AND NEWS

The organization meeting of the American Society of Mammalogists was held in the New National Museum, Washington, D. C., April 3 and 4, 1919, with a charter membership of over two hundred and fifty, of whom sixty were in attendance at the meeting. The following officers were elected: C. HART MERRIAM, *President;* E. W. NELSON, *First Vice-President;* WILFRED H. OSGOOD, *Second Vice-President;* H. H. LANE, *Recording Secretary;* HARLEY H. T. JACKSON, *Corresponding Secretary;* WALTER P. TAYLOR, *Treasurer.* The *Councilors* are: GLOVER M. ALLEN, R. M. ANDERSON, J. GRINNELL, M. W. LYON, W. D. MATTHEW, JOHN C. MERRIAM, GERRIT S. MILLER, JR., T. S. PALMER, EDWARD A. PREBLE, WITMER STONE, and N. HOLLISTER, *Editor.*

Committees were appointed on: *Life histories of mammals,* C. C. ADAMS, *Chairman; Study of game mammals,* CHARLES SHELDON, *Chairman; Anatomy and phylogeny,* W. K. GREGORY, *Chairman;* and *Bibliography,* T. S. PALMER, *Chairman.*

The policy of the society will be to devote its attention to the study of mammals in a broad way, including life histories, habits, relations to plants and animals, evolution, paleontology, anatomy, and other phases.

Publication of the Journal of Mammalogy, in which popular as well as technical matter will be presented, will start this year.

At the meeting of the National Academy of Sciences held in Washington on April 28–30, 1919, the following fifteen persons were elected to membership: Prof. JOSEPH BARRELL, geologist, Yale University; Dr. GARY NATHAN CALKINS, zoologist, Columbia University; Dr. HEBER DOUST CURTIS, astronomer, Lick Observatory; Mr. GANO DUNN, electrical engineer, New York City; Dr. LAWRENCE JOSEPH HENDERSON, biologist, Harvard University; Dr. REID HUNT, pharmacologist, Harvard University; Prof. TREAT BALDWIN JOHNSON, chemist, Yale University; Prof. WINTHROP JOHN OSTERHOUT, botanist, Harvard University; Prof. FREDERICK HANLEY SEARES, astronomer, Mt. Wilson Observatory, California; Dr. WILLIAM ALBERT SETCHELL, botanist, University of California; Maj. Gen. GEORGE OWEN SQUIER, electrical engineer, Signal Corps, U. S. A.; Prof. AUGUSTUS TROWBRIDGE, physicist, Princeton University; Prof. OSWALD VEBLEN, mathematician, Princeton University; Dr. ERNEST JULIUS WILCZYNSKI, mathematician, University of Chicago; Prof. EDWIN BIDWELL WILSON, physicist, Massachusetts Institute of Technology. Dr. C. G. ABBOT was elected Home Secretary of the Academy.

Rear Admiral JOHN E. PILLSBURY, U. S. N., Retired, was elected President of the National Geographic Society on April 17, as successor to Mr. OTTO H. TITTMANN, who retired from the office on account of ill health. Rear Admiral ROBERT E. PEARY, U. S. N., Retired, was elected a member of the Board of Managers to fill the vacancy caused by the death of the late Brig. Gen. JOHN M. WILSON, U. S. A.

Dr. C. G. ABBOT, of the Astrophysical Observatory, Smithsonian Institution, sailed for South America on May 1 to inspect the Smithsonian solar constant observing station at Calama, Chile, and to observe the total solar eclipse at La Paz, Bolivia. He expects to return to Washington in August.

Prof. J. M. ALDRICH has been appointed Associate Curator of the Division of Insects in the National Museum. Prof. Aldrich was formerly with the University of Idaho, but more recently has been working with the Bureau of Entomology. He is one of the best-known Dipterists in North America and is the author of our most recent catalogue of these insects.

Dr. GEORGE FERDINAND BECKER, geologist in charge of the division of physics and chemistry, U. S. Geological Survey, and a charter member of the ACADEMY, died on April 20, 1919, in his seventy-third year. Dr. Becker was born in New York City on January 5, 1847. He began work as a constructing engineer, with the Joliet Iron and Steel Company, then after a few years became instructor in mining and metallurgy at the University of California. He was appointed geologist in the U. S. Geological Survey in 1879, and was thus associated with the development of the Survey almost from its beginning. He approached geologic problems from the viewpoint of the mathematical physicist and engineer, and made many contributions to geophysics, as well as to special fields in both physics and geology. The establishment of the Geophysical Laboratory of the Carnegie Institution grew out of investigations begun by him under a grant from that Institution. He was a member of the National Academy of Sciences, the Geological Society of Washington, and other American geological and engineering societies, including the Geological Society of America of which he was president in 1914.

Dr. F. RUSSELL V. BICHOWSKY, of the Geophysical Laboratory, has been granted by the National Research Fellowship Board a research fellowship in chemistry at the University of California.

E. D. BROMLEY, of the U. S. Coast and Geodetic Survey, has been engaged in a triangulation in the northern half of Chesapeake Bay, to determine the geographic positions of certain points used in testing the long-range artillery at Aberdeen, Maryland.

Dr. KEIVIN BURNS, of the division of optics, Bureau of Standards, resigned from the Bureau on May 1. He will spend a year on the Pacific Coast and will devote his attention to the use of dicyanin in astrophysical research.

Mr. J. C. CRAWFORD, formerly Associate Curator of the Division of Insects of the National Museum, has resigned and accepted a position in the Bureau of Entomology.

Captain S. T. DANA has resumed his duties with the Forest Service as Assistant Chief of Forest Investigations. During the war he was on the General Staff as secretary of the Army Commodity Committee on Lumber, and in charge of determining wood requirements of the Army.

Col. E. LESTER JONES, Superintendent of the U. S. Coast and Geodetic Survey, has been named by the King of Italy an officer of the Order of S. S. Maurizo e Lazzaro.

Dr. LEONARD B. LOEB, formerly of the Bureau of Standards, has been granted a research fellowship in physics by the National Research Fellowship Board.

Major A. O. LEUSCHNER has returned to Washington from a furlough in California and is at present acting chairman of the Division of Physical Sciences of the National Research Council.

Dr. SAMUEL C. PRESCOTT, of the Massachusetts Institute of Technology, formerly major in the Sanitary Corps, U. S. A., has been appointed expert in charge of dehydration investigations in the Bureau of Chemistry, Department of Agriculture, and will continue the investigations on this subject carried on during the war under the direction of the War Department.

Mr. HOMER P. RITTER, for many years an officer of the U. S. Coast and Geodetic Survey and a member of the Mississippi River Commission, died at the Emergency Hospital on April 21, 1919, in his sixty-fifth year. He was returning from a meeting of the Mississippi River Commission at Memphis and was taken ill on the train. Mr. Ritter was born in Cleveland, Ohio, March 4, 1855. After receiving his technical training at the Columbia School of Mines he was employed for several years on railway surveys. He entered the Coast and Geodetic Survey in 1885, and had been employed on field work in all parts of the United States and in Alaska. He succeeded HENRY L. MARINDIN as a member of the Mississippi River Commission in 1904. He was a member of the Society of Engineers.

Mr. R. SANO, founder and director of the meteorological observatory of Kanayama, near Sendai, Japan, visited Washington in April.

Mr. A. H. SMITH, of the rubber laboratory, Bureau of Standards, will leave the Bureau on July 1, to accept a position with the Goodyear Rubber Company, at Akron, Ohio.

Mr. WM. SCHAUS has recently been appointed as Assistant Curator in the Division of Insects of the National Museum. Mr. Schaus is a student of Lepidoptera and in recent years has spent much time in tropical America where he made large collections which have been given to the National Museum.

Dr. C. H. T. TOWNSEND sailed, early in April, for Brazil where he has accepted a position as entomologist for the Brazilian government. Dr. Townsend has been with the Bureau of Entomology and has spent most of his time studying the Muscoid Diptera.

A Washington Section of the American Society of Mechanical Engineers has been organized, with the following officers: S. W. STRATTON, Bureau of Standards, chairman; Maj. J. H. KLINCK, vice-chairman; Prof. GEO. A. WESCHLER, Catholic University, secretary; H. L. WHITTEMORE and A. E. JOHNSON, members of executive committee. The Section held a meeting with the following program: S. W. STRATTON, *Standardization of screw threads;* Col. E. C. PECK, *Gage work of the Ordnance Department for the U. S. Army;* H. L. VAN KEUREN, *Certification of gages at the Bureau of Standards;* C. G. PETERS, *The use of interference methods in calibrating length standards.*

The Medical Society of the District of Columbia, one of the affiliated societies of the ACADEMY, is raising a fund of $100,000 for the erection of a permanent home for the Society. A site on M street near Connecticut Avenue has already been purchased. Dr. EDWARD Y. DAVIDSON is chairman of the building committee.

NATIONAL RESEARCH COUNCIL

One year ago this JOURNAL[1] outlined the war reorganization of the National Research Council which went into effect on April 1, 1918. With the coming of peace this plan of organization has been elaborated and the Council placed on a continuing basis. The present organization was adopted on February 11, 1919, by the council of the National Academy of Sciences, and is, in brief outline, as follows:

The membership is to consist of: (1) Representatives of national scientific and technical societies; (2) representatives of the federal government; (3) representatives of other research organizations, and other persons whose aid may advance the objects of the Council. The membership is organized into thirteen divisions, grouped into two classes, as below:

(*a*) Divisions dealing with general relations: I, Government Division. II, Foreign Relations. III, States Relations. IV, Educational Relations. V, Industrial Relations. VI, Research Information Service.[2]

(*b*) Divisions of science and technology: VII, Physical Sciences. VIII, Engineering. IX, Chemistry and Chemical Technology. X, Geology and Geography. XI, Medical Sciences. XII, Biology and Agriculture. XIII, Anthropology and Psychology.

Each division in the class of science and technology, and some of the divisions in the class of general relations, will have a salaried chairman, who will be stationed in Washington. The affairs of the Council will be administered by an executive board, which will include, in addition to *ex-officio* members from the Council itself, the President and Home Secretary of the National Academy and the President of the American Association for the Advancement of Science. The Chairman of the

[1] This JOURNAL 8: 337. 1918.

[2] See this JOURNAL 8: 223, 339. 1918.

Council will receive a salary of $10,000 per year, and the chairmen of divisions, as well as the executive secretary of the Council, will receive $6000.

Prof. J. C. MERRIAM, of the University of California, is at present Acting Chairman of the Council. Officers of some of the divisions have been selected as follows: Physical Sciences, Maj. C. E. MENDENHALL, chairman; Engineering, Dr. H. M. HOWE, chairman, Mr. G. H. CLEVENGER, vice-chairman; Chemistry and Chemical Technology, Lieut. Col. W. D. BANCROFT, chairman, Prof. JULIUS STIEGLITZ, vice-chairman; Biology and Agriculture, Prof. C. E. MCCLUNG, chairman, Prof. L. R. JONES, vice-chairman.

Further information on the organization of the Council will be presented as soon as the organization is completed.

UNION OF SCIENTIFIC AND TECHNICAL WORKERS

A mass meeting of scientific and technical employees of the federal Government, called by a committee consisting of H. L. SHANTZ (Agriculture), W. L. THURBER (Interior), L. W. CHANEY (Labor), P. G. AGNEW (Commerce), and F. L. LEWTON (Smithsonian), was held at the National Museum on Thursday, May 8, 1919. The attendance was about 400. R. H. TRUE, of the Department of Agriculture, presided. The call for the meeting stated the following reasons for the formation of an organization:

Improvement of conditions and facilities for more effective scientific and technical work; adequate presentation of the needs and results of such work to the public and to legislative and administrative officers; greater freedom in both official and non-official activities; just and reasonable salaries based on service performed and the economic and social conditions which prevail; greater public recognition of the aims and purposes of research; advancement of science and technology as an essential element of national life.

After a statement concerning the British National Union of Scientific Workers and similar movements in Great Britain, the following three plans were discussed:

(1) To work only through existing organizations, namely, the ACADEMY and the National Research Council; (2) to form an independent organization of those federal employees doing scientific or technical work; (3) to form a scientific and technical branch of Federal Employees' Union No. (2).[1]

Plan No. (1) received very little support. A large number of speakers discussed plans Nos. (2) and (3). It was generally agreed that organization was necessary; that the situation of the scientific and technical bureaus is serious, as the better men tend to leave and can not be replaced under the existing salary scale; and that coöperation with existing organizations is not excluded by either Plan (2) or Plan (3).

[1] Federal Employees' Union No. 1 was organized in San Francisco. No. 2 embraces practically all governmental bureaus in the District of Columbia.

Some of the arguments and assertions presented were as follows:

For Plan (2) and against Plan (3): A general employees' union does not and can not represent the special problems of the scientific group. The scientist does not work by hours. The scientist is much more easily appealed to by proper conditions and by recognition than by financial considerations. The scientist works best under conditions similar to those of the university teacher. Independence of action would be too greatly limited by affiliation with the Union. Many things are done in the name of organized labor which are not approved by the great majority of scientists. A political threat through affiliation with the American Federation of Labor is an undesirable method. The government employee owes full allegiance to the government and should join no organization which might conceivably interfere with that allegiance. Affiliation will keep out many who would join an independent organization. If found desirable, affiliation with the union may be brought about later.

For Plan (3) and against Plan (2): An independent organization would not be large enough to exert any influence. Affiliation will help to bring the needs of the scientific profession before the public. There is an unfounded belief in the public mind that the scientific investigator is not a producer; independent organization would only tend to confirm such a prejudice. The American Federation of Labor has no control over the action of its constituent unions. All organizations take actions that are not approved by considerable fractions of their membership. The plan does not involve a political threat. Congress, in general, desires information and wishes to act justly toward the federal employees and has welcomed the aid of the Union. The constitution of the Union forbids strikes, either direct or sympathetic. Over 550 scientific and technical workers are already a part of the Union's 21,000 members. The Union has in three years secured the following benefits to all federal employees: A general increase of salary; the defeat of the Borland amendment to increase the hours; progress on a retirement plan; and the Reclassification Commission. The Joint Congressional Reclassification Commission, which wishes to deal with employees through organizations and not as individuals, is now at work and immediate action is necessary; Union funds and machinery are available for immediate action.

The meeting voted 185 to 132 in favor of Plan No. (3). R. H. TRUE was elected chairman, and P. G. AGNEW, of the Bureau of Standards, secretary, of the temporary organization, consisting of a general interim committee composed of the chairman and secretary and representatives from the scientific and technical bureaus, one representative for each 20 members.